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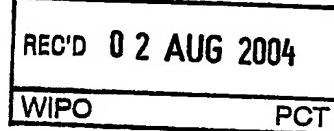
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APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A  
FILING DATE.

APPLICATION NUMBER: 60/464,582

FILING DATE: April 22, 2003

RELATED PCT APPLICATION NUMBER: PCT/US04/11955



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## PROVISIONAL APPLICATION COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION under 37 CFR 1.53(b)(2)

Date : April 22, 2003

Reference No. : 0021746-0002

INVENTORS(S)/APPLICANTS(S) (LAST NAME, FIRST NAME, MIDDLE INITIAL, RESIDENCE (CITY AND EITHER STATE OR FOREIGN COUNTRY))

SHIN, Daniel D.  
Los Angeles, California

CARMAN, Gregory P.  
Los Angeles, California

Additional inventors are being named on separately numbered sheets attached hereto.

### TITLE OF THE INVENTION (280 characters max)

### MICROMEMBRANE ACTUATOR

#### ENCLOSED APPLICATION PARTS:

- Specification: total number of pages 10 (Description = 9 and Abstract = 1)  
 Drawings (4 pages)  
 Small entity claimed under 37 CFR 1.27.  
 Assignment  
 Other (Specify): Additional subject matter (4 pages)

#### METHOD OF PAYMENT

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Please address all correspondence to J.D. Harriman II, COUDERT BROTHERS LLP, 333 South Hope Street, 23<sup>rd</sup> Floor, Los Angeles, California 90071, U.S.A. Telephone (213) 229-2900.

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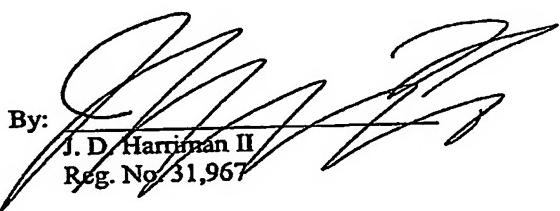
Jose Ramos

Respectfully submitted,

COUDERT BROTHERS LLP

By:

J. D. Harriman II  
Reg. No. 31,967



PROVISIONAL APPLICATION FILING ONLY

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0021746-0002

UNITED STATES PROVISIONAL PATENT APPLICATION

FOR

**MICROMEMBRANE ACTUATOR**

INVENTOR:

DANIEL D. SHIN  
GREGORY P. CARMAN

PREPARED BY:

COUDERT BROTHERS LLP  
333 SOUTH HOPE STREET  
23<sup>RD</sup> FLOOR  
LOS ANGELES, CALIFORNIA 90071  
Phone: 213-229-2900  
Fax: 213-229-2999

LOSANGELES 101295v2

## BACKGROUND OF THE INVENTION

### 1. FIELD OF THE INVENTION

The present invention relates to the field of micromembrane actuators.

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### 2. BACKGROUND ART

The continuing miniaturization of devices has created the need for miniature versions of well known components. A typical component in many mechanical and electro-mechanical systems is an actuator which can produce an action in response to an input. In some cases the actuator will transform a first force into a second force or trigger an operation in response to some application of an input.

One actuator used in miniature devices is a micropump. A micropump is a device for transferring fluid from one place to another. One type of prior art micropump uses a "shape memory alloy" (SMA) to provide the force that causes the pumping to take place. Shape memory alloys (SMA) form a group of metals which have the property that, when deformed while below a martensite finish temperature and then heated to above an

austenite temperature, the alloy returns to its shape existing before the deformation. One such alloy is NiTi.

Prior art micro pump devices suffer from a number of disadvantages. An early device used tow antagonistic NiTi membranes. This device suffered from low flow rates and limited force output. Another prior art micro pump used a NiTi membrane biased with nitrogen gas. Besides the complications inherent in the nitrogen biased design, the pump also lacked large force and flow rates. Some prior art attempts have included a bimorph silicon/NiTi design. This design suffered from operating frequency limitations that limited flow rate.

SUMMARY OF THE INVENTION

The present invention provides a thin film SMA micro pump that has high work density and high frequency response. The invention uses a miniature SMA pump to rectify liquid to achieve stroke. The invention manipulates the fluid flow to have forced convection cooling on the SMA membrane, eliminating the insufficient cooling of prior art designs. The result is an improved design with operation at flow rates well in excess of prior art designs.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 illustrates a single membrane pump actuator.

Figure 2 is a cross sectional view of Figure 1.

Figure 3 is a cross sectional view of a deformed SMA membrane under bias pressure.

Figure 4 is front view of a pumping chamber.

Figure 5 is a perspective view of the four-membrane pump actuator formed in accordance with the present invention.

Figure 6 illustrates a perspective view of a membrane of one embodiment of the invention.

DETAILED DESCRIPTION

A micromembrane actuator is described. In the following description, numerous details are set forth in order to provide a more thorough description of the present invention. It will be apparent, however, to one skilled in the art, that the present invention may be practiced without these specific details. In other instances, well known features have not been described in detail so as not to unnecessarily obscure the present invention.

A perspective view of an embodiment of the present invention is illustrated in Figure 1. The actuator comprises a pumping chamber 2a, O-ring 4, inlet portholes 5, outlet portholes 6, inlet 7, and lid 1 with SMA membrane 3. The O-ring 4 provides a seal between the lid 1 and the pumping chamber 2a. The inlet 7 is joined to a check valve (not shown) to provide for one way fluid flow at that port. An outlet port 10 (Figure 4) is used to remove the fluid from the pumping chamber 2a. The outlet port 10 also may have a check valve (not shown) to prevent reverse fluid flow in the pumping chamber.

The operation of the invention is the introduction of fluid via the inlet port 7 and the pumping of that fluid out the outlet port 10 by action of the membrane 3. Referring briefly to Figure 3, a cross section of SMA membrane 3 is shown. The rest position of the membrane 3 is in a concave state with respect to the pumping chamber. This forms a cavity 9 between the body of the pumping chamber and the membrane. This cavity is contained within the O-ring 4.

An application of current to the membrane 3 results in a deformation of the membrane 3 such that the radius of curvature is reduced, resulting in a pressure increase into the pump chamber 2a to apply the desired pumping force. Consider a cycle of operation during use of the pump of the invention. Cool liquid enters the pumping chamber 2a via inlet 7. As the fluid fills the pumping chamber, some of it flows out through the inlet porthole 5 to the cavity 9. The cool liquid impinges on the hot membrane 3 and cools it, allowing higher operating frequency than possible without this cooling function. A current is applied to the membrane 3 that deforms it downward, reducing the volume in the cavity 9 and thus producing a pumping force to the now heated liquid in the pumping chamber. Liquid is forced through the outlet ports 6 back into the pumping chamber and out the outlet 10 (forcing the check valve open).

As liquid exits the pumping chamber 2a, the internal pressure decreases. Charge is removed from the membrane and the internal bias pressure causes cool liquid to be drawn into the chamber via inlet 7. The cool liquid adds pressure to the pumping chamber, causing the membrane to be deformed outward (and again cooling the membrane). Charge is again applied to the membrane and the pumping cycle begins again.

Figure 5 illustrates an embodiment with multiple membranes used in parallel to increase the volume flow rate of the system. Consider a cube or box shaped pumping chamber having six sides. The present invention contemplates any number of

membranes from 1 to six to be used with the present invention. Figure 5 illustrates a four membrane configuration. Charge is applied to the membranes simultaneously in one embodiment to multiply the pumping force of the invention.

Figure 6 is a perspective view of a membrane for use in one embodiment of the invention. In the example shown, the membrane has a thickness of 5 micrometers and dimensions of 17 mm wide and 17 mm long. The membrane need not be square but may be any suitable shape without departing from the scope of the invention.

In one embodiment a circular area of approximate diameter 11 mm is the area where the bias load is applied. Current load of approximately 21 amps is applied in a cycle of 1 cycle @ 100Hz = 0.01 seconds.

In one embodiment the composition of the membrane is approximately 53% Titanium and approximately 47% Nickel.

CLAIMS OF THE INVENTION

We claim:

1. A pump comprising:

a pumping chamber having a fluid inlet and a fluid outlet;  
a lid coupled to said pumping chamber, said lid including a deformable membrane  
such that a cavity is formed between said lid and said pumping chamber;  
an inlet port formed in said pumping chamber for permitting fluid to be  
introduced to said cavity;  
at least one outlet port formed in said pumping chamber for permitting fluid to  
flow from said cavity to said pumping chamber;  
means for deforming said membrane to reduce the size of said cavity and thereby  
introduce a pressure to fluid in said cavity and said pumping chamber.

ABSTRACT OF THE DISCLOSURE

The present invention provides a thin film SMA micro pump that has high work density and high frequency response. The invention uses a miniature SMA pump to rectify liquid to achieve stroke. The invention manipulates the fluid flow to have forced convection cooling on the SMA membrane, eliminating the insufficient cooling of prior art designs. The result is an improved design with operation at flow rates well in excess of prior art designs.

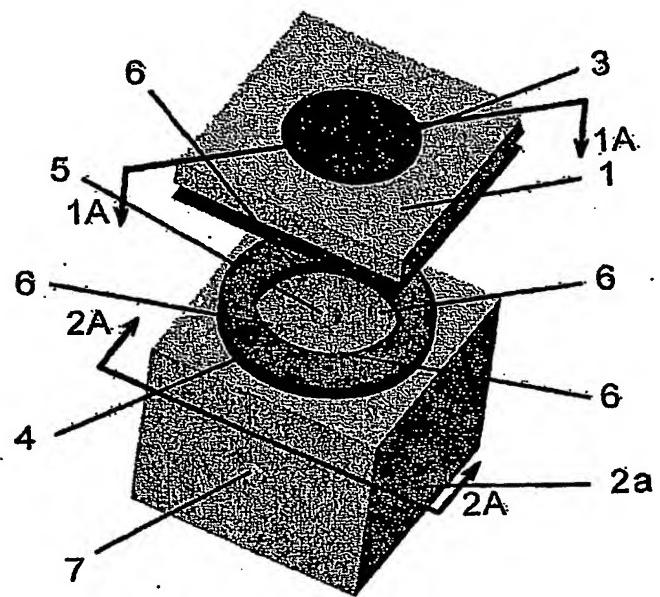


FIG. 1

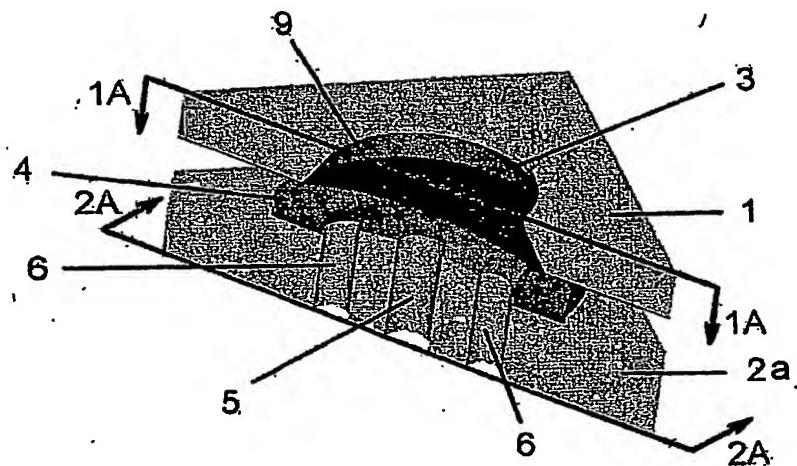


FIG. 2

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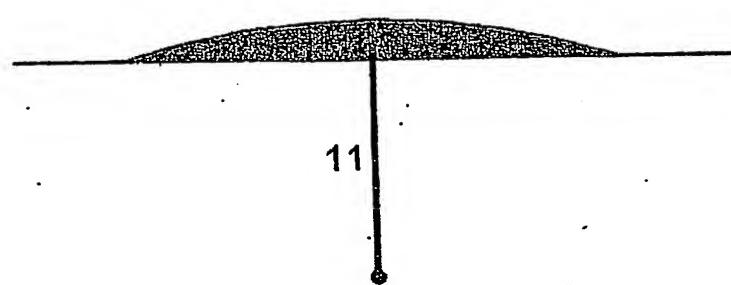


FIG. 3

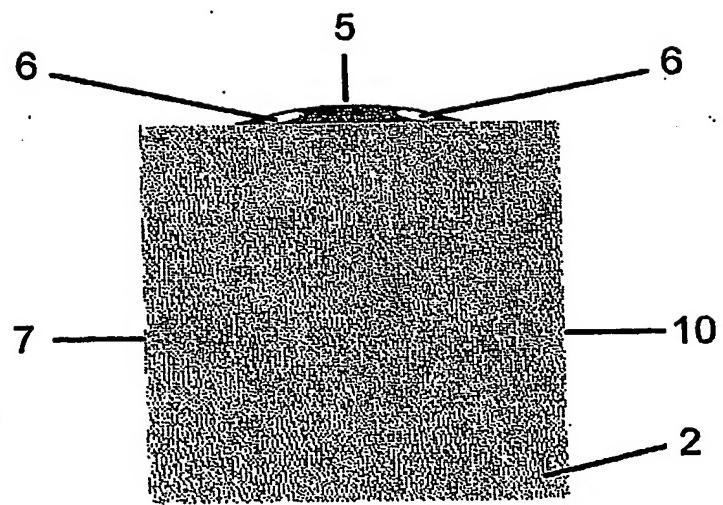


FIG. 4

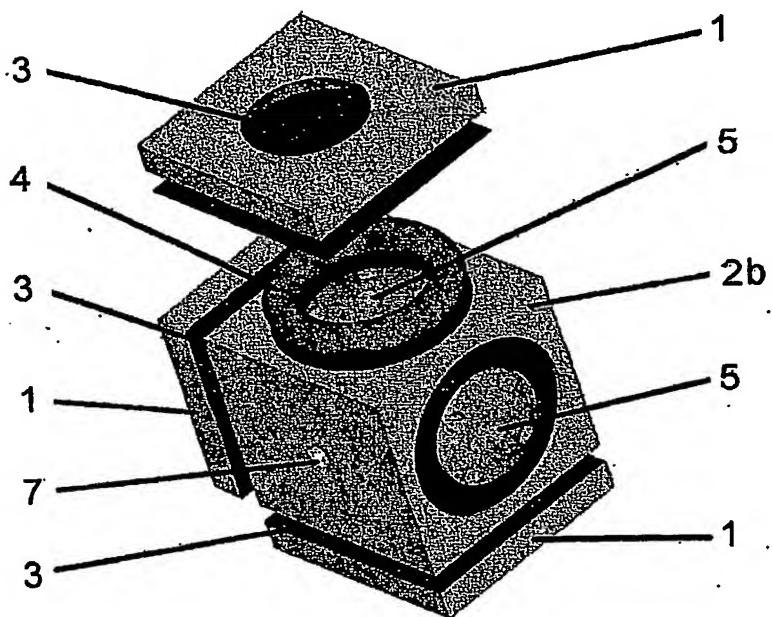
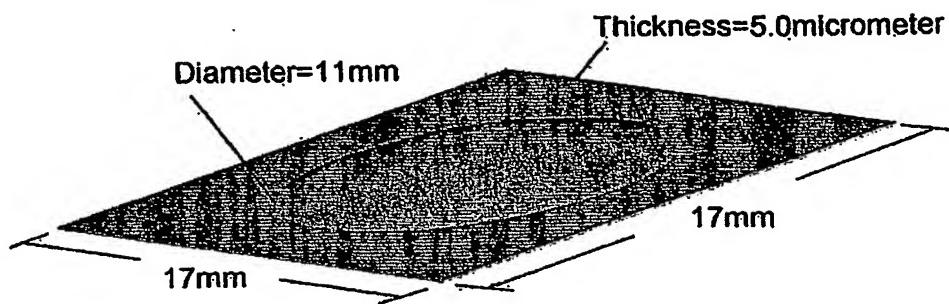


FIG. 5



*Dimensions of the membrane:* diameter refers to the area where the bias load is applied.

*Current applied to the membrane:* ~21amps

*Timing of the pump cycle:* 1 cycle @ 100Hz = 0.01sec  
@ 100Hz, heating time could vary from 1-10% (heating time = 0.0001-0.001 seconds & cooling time = 0.9999-0.999 seconds)

Figure 6